US007949192B2

(12) **United States Patent**
Nagy

(10) **Patent No.: US 7,949,192 B2**
(45) **Date of Patent: May 24, 2011**

(54) **TECHNIQUES FOR CONVERTING ANALOG MEDICAL VIDEO TO DIGITAL OBJECTS**

(75) Inventor: **Paul Nagy**, Ellicott City, MD (US)

(73) Assignee: **University of Maryland, Baltimore**, Baltimore, MD (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 1024 days.

(21) Appl. No.: **11/746,035**

(22) Filed: **May 8, 2007**

(65) **Prior Publication Data**

US 2008/0123915 A1 May 29, 2008

Related U.S. Application Data

(60) Provisional application No. 60/799,295, filed on May 10, 2006.

(51) **Int. Cl.**
G06K 9/72 (2006.01)
G06F 17/30 (2006.01)

(52) **U.S. Cl.** **382/229**; 707/762

(58) **Field of Classification Search** .... None
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,950,207	A *	9/1999	Mortimore et al.	1/1
2002/0080392	A1 *	6/2002	Parvulescu et al.	358/1.15
2004/0059756	A1 *	3/2004	Mochizuki	707/201
2004/0136602	A1 *	7/2004	Nagaraj et al.	382/240
2005/0131558	A1 *	6/2005	Braithwaite et al.	700/94
2006/0149601	A1 *	7/2006	Langhofer et al.	705/3
2008/0114481	A1 *	5/2008	Braithwaite et al.	700/94
2008/0123915	A1 *	5/2008	Nagy	382/128

OTHER PUBLICATIONS

NEMA, Digital Imaging and Communication in Medicine (DICOM) Part 1: Introduction and Overview, /dicom/2004.html/04_01PU. PDF, Jan. 1, 2004, Publisher: National Electrical Manufacturers Association, Published in: Rosslyn, VA, USA and Internet:medical. nema.org.

* cited by examiner

Primary Examiner — Bhavesh M Mehta
Assistant Examiner — Tahmina Ansari
(74) *Attorney, Agent, or Firm* — Evans & Molinelli PLLC; Eugene Molinelli

(57) **ABSTRACT**

Techniques for converting analog medical video data to digital objects include receiving a digital video signal. The signal is produced by converting an analog video signal from playing a legacy analog medical video medium on an appropriate analog video player. Without human intervention, a first portion of a video frame of the digital video signal is determined where characters are imaged onto the analog medical video by the legacy system. The first portion of the video frame is processed in a video optical character recognition process to generate first character data. Non-video descriptive data associated with the analog medical video data is determined based on the first character data. Digital video data based on the digital video signal is stored in association with the non-video descriptive data. These techniques allow one or more extensive analog medical video libraries to be converted quickly and at low cost in human labor.

20 Claims, 5 Drawing Sheets

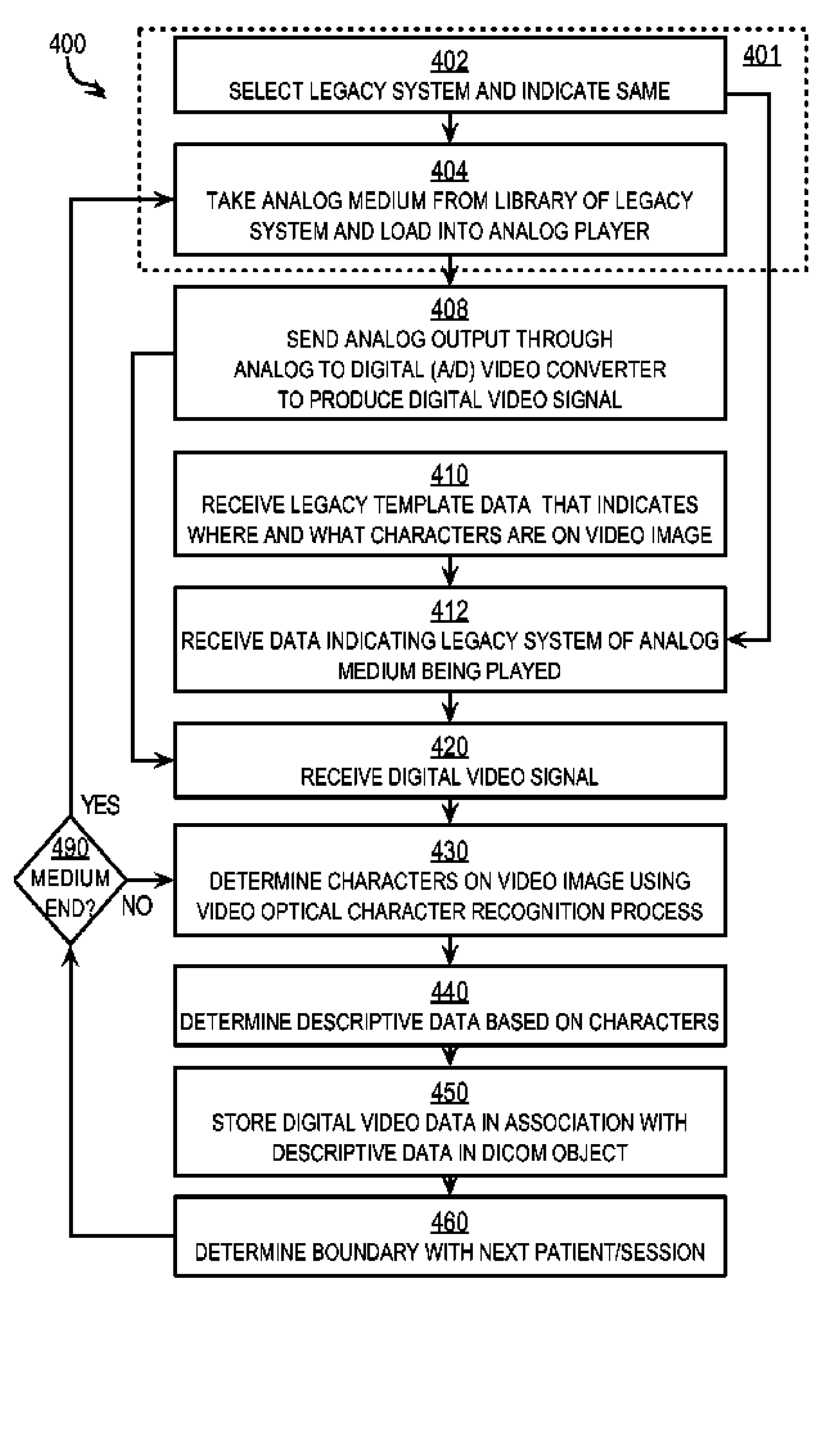


FIG. 1

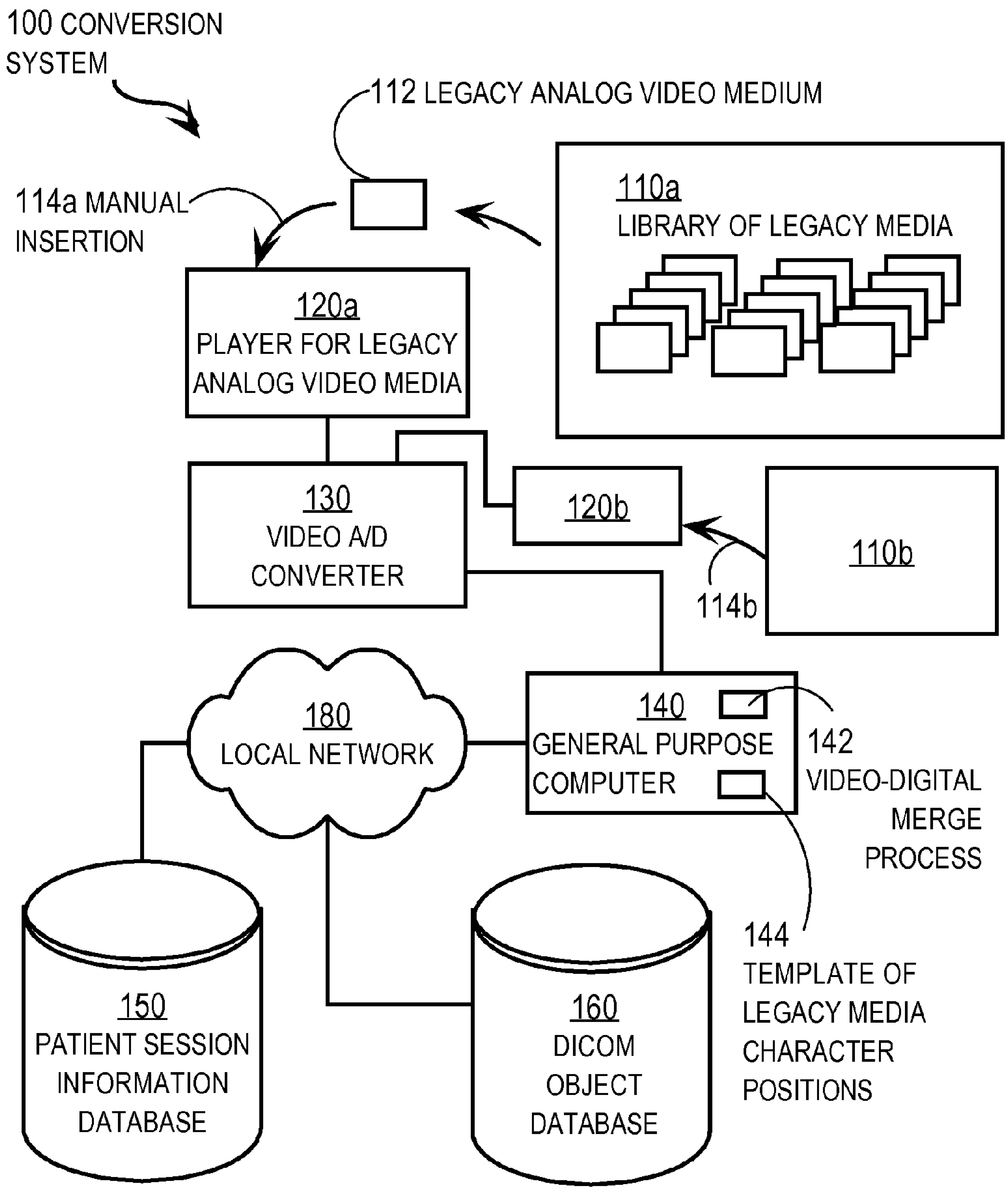

100 CONVERSION SYSTEM
112 LEGACY ANALOG VIDEO MEDIUM
114a MANUAL INSERTION
110a
LIBRARY OF LEGACY MEDIA
120a
PLAYER FOR LEGACY ANALOG VIDEO MEDIA
130
VIDEO A/D CONVERTER
120b
110b
114b
180
LOCAL NETWORK
140
GENERAL PURPOSE COMPUTER
142
VIDEO-DIGITAL MERGE PROCESS
144
TEMPLATE OF LEGACY MEDIA CHARACTER POSITIONS
150
PATIENT SESSION INFORMATION DATABASE
160
DICOM OBJECT DATABASE

FIG. 2A

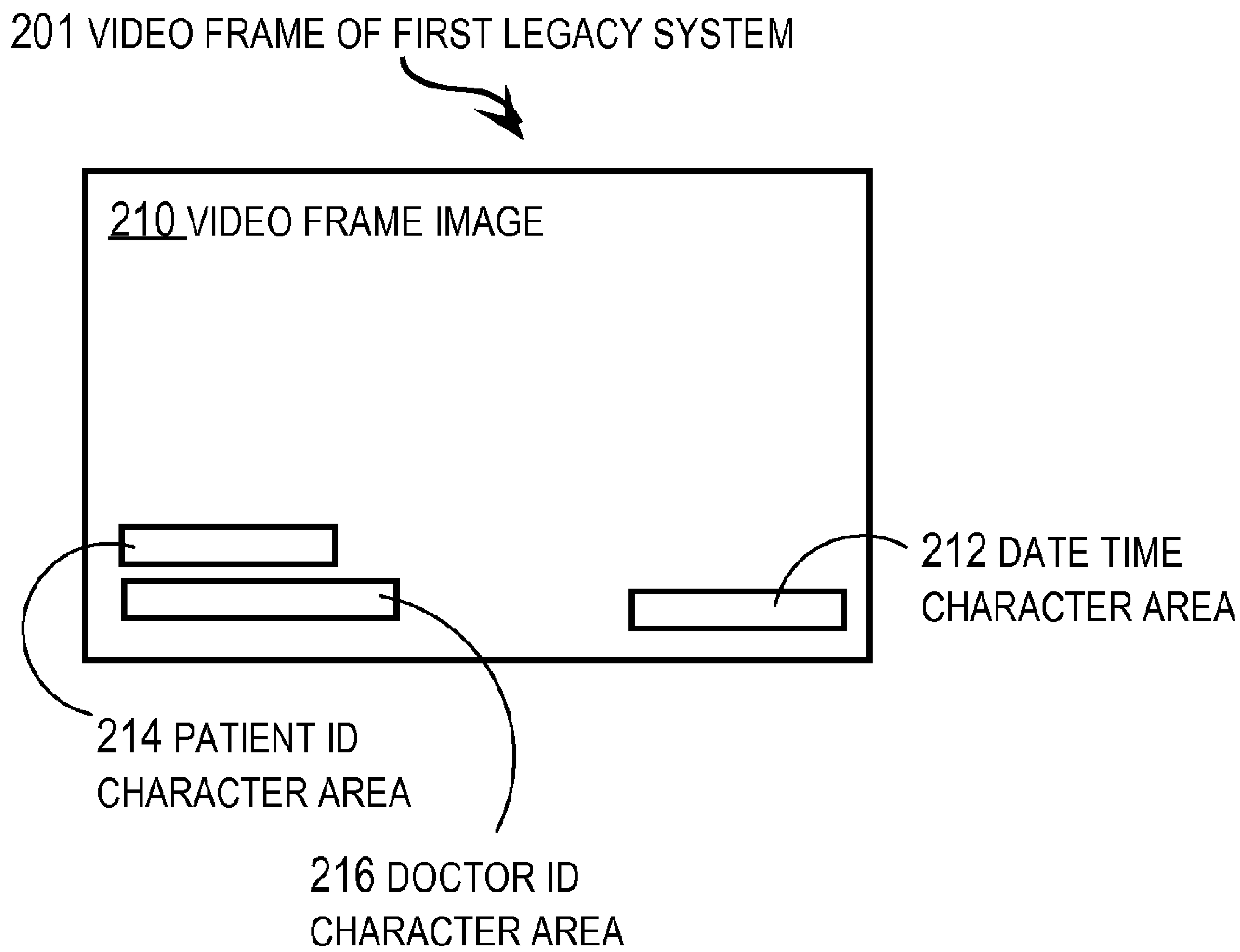

201 VIDEO FRAME OF FIRST LEGACY SYSTEM
210 VIDEO FRAME IMAGE
212 DATE TIME CHARACTER AREA
214 PATIENT ID CHARACTER AREA
216 DOCTOR ID CHARACTER AREA

FIG. 2B

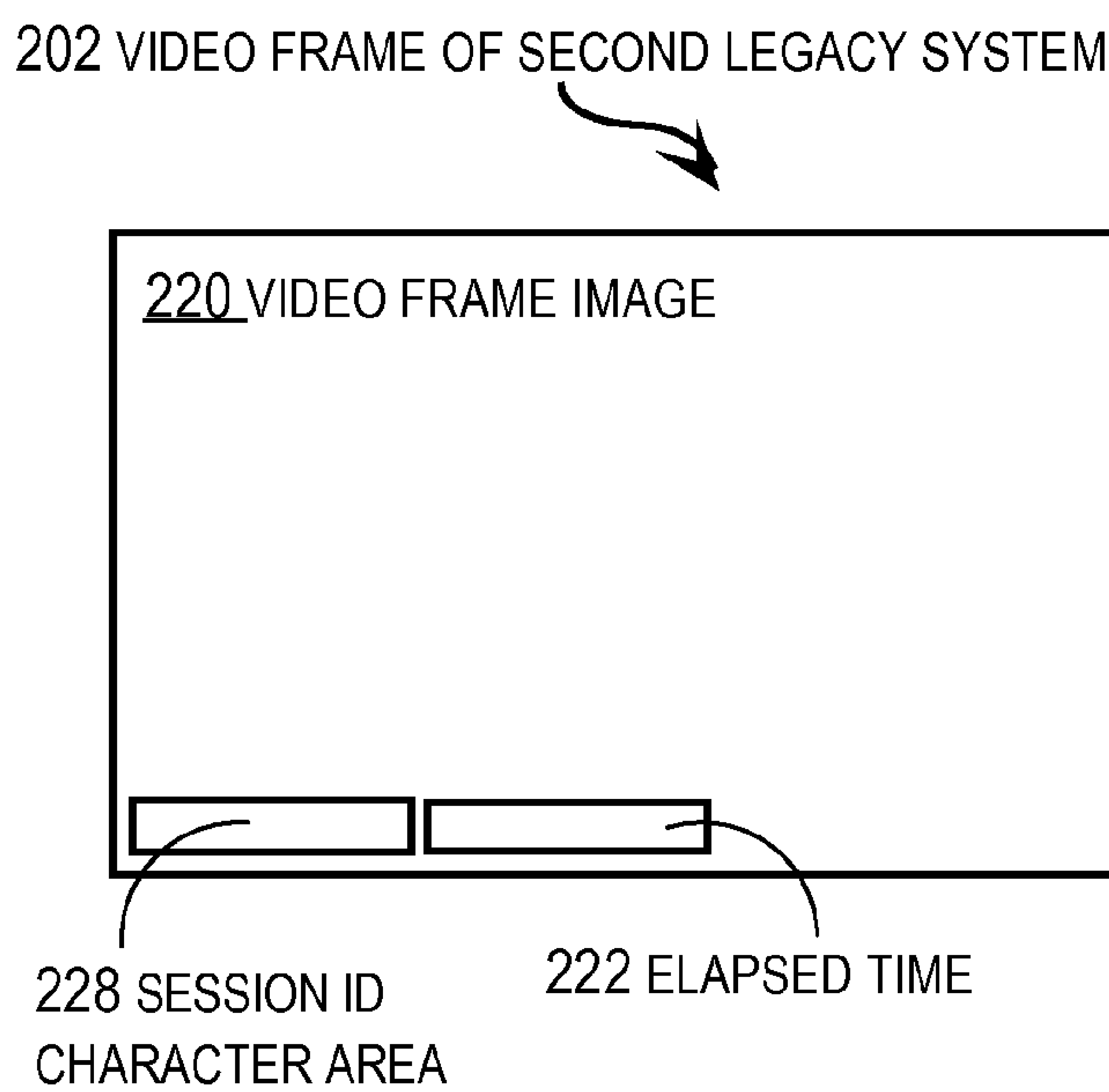

202 VIDEO FRAME OF SECOND LEGACY SYSTEM
220 VIDEO FRAME IMAGE
228 SESSION ID CHARACTER AREA
222 ELAPSED TIME

FIG. 3

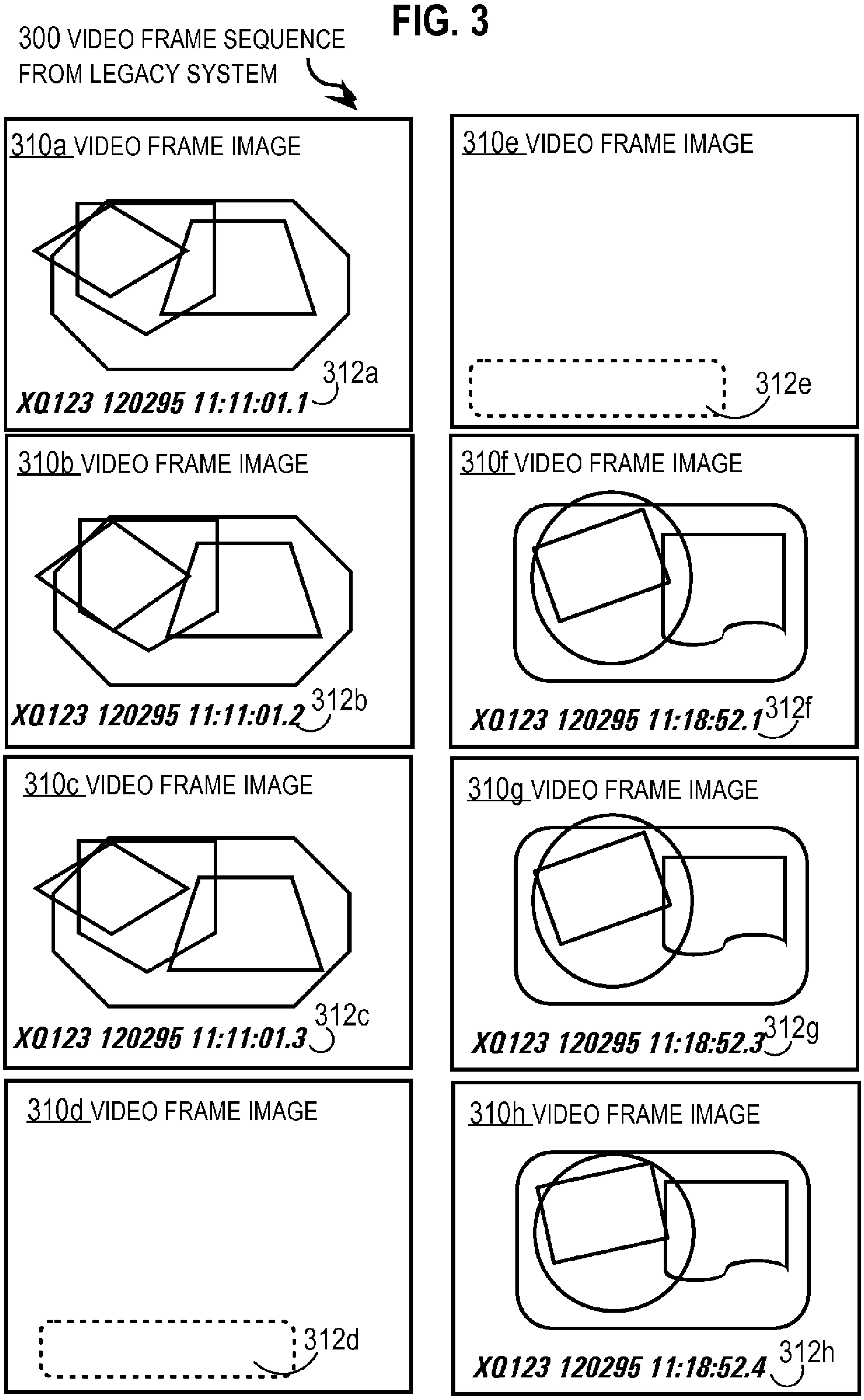

300 VIDEO FRAME SEQUENCE FROM LEGACY SYSTEM
310a VIDEO FRAME IMAGE
312a
XQ123 120295 11:11:01.1
310b VIDEO FRAME IMAGE
312b
XQ123 120295 11:11:01.2
310c VIDEO FRAME IMAGE
312c
XQ123 120295 11:11:01.3
310d VIDEO FRAME IMAGE
312d
310e VIDEO FRAME IMAGE
312e
310f VIDEO FRAME IMAGE
312f
XQ123 120295 11:18:52.1
310g VIDEO FRAME IMAGE
312g
XQ123 120295 11:18:52.3
310h VIDEO FRAME IMAGE
312h
XQ123 120295 11:18:52.4

FIG. 4

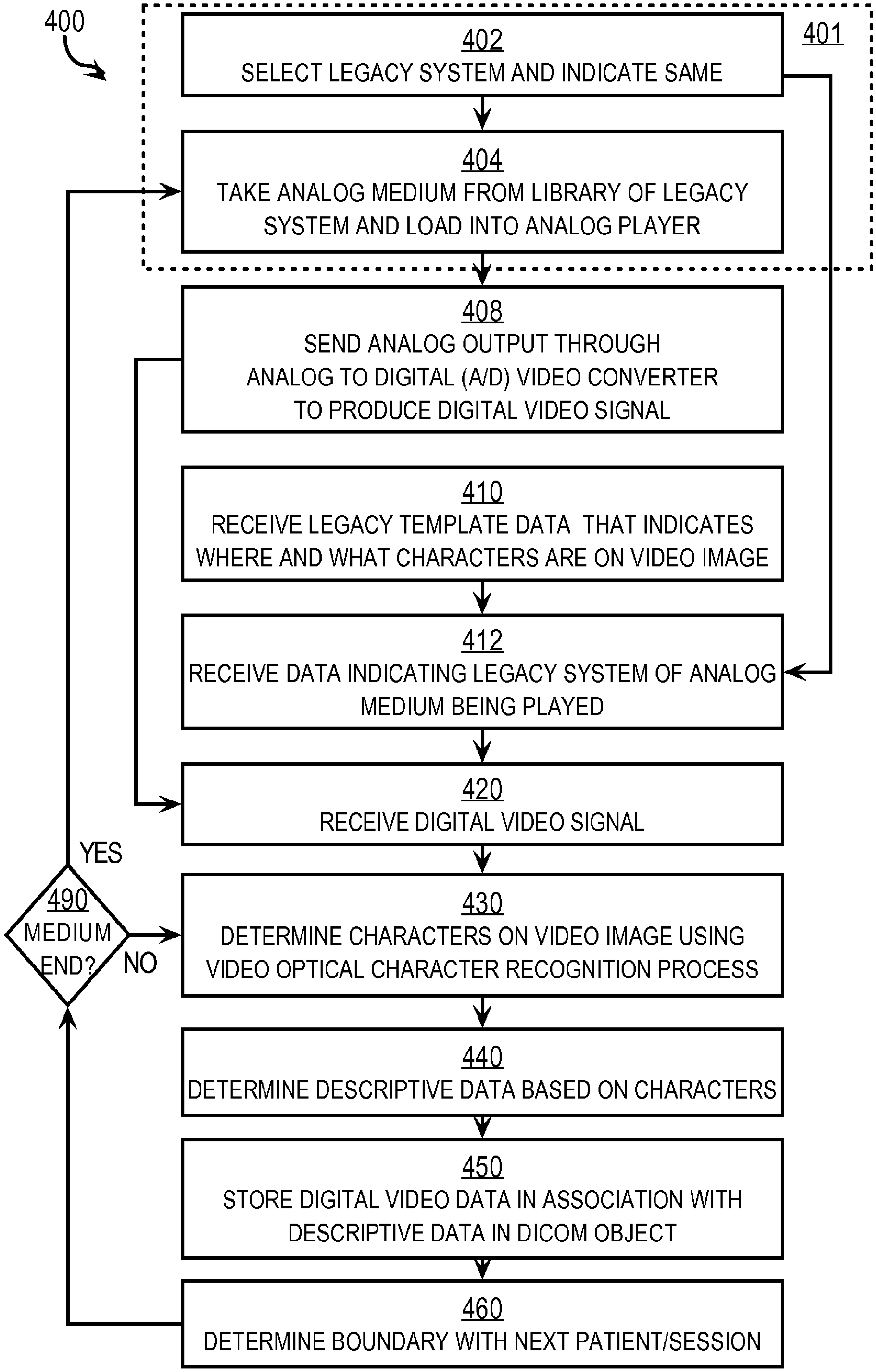
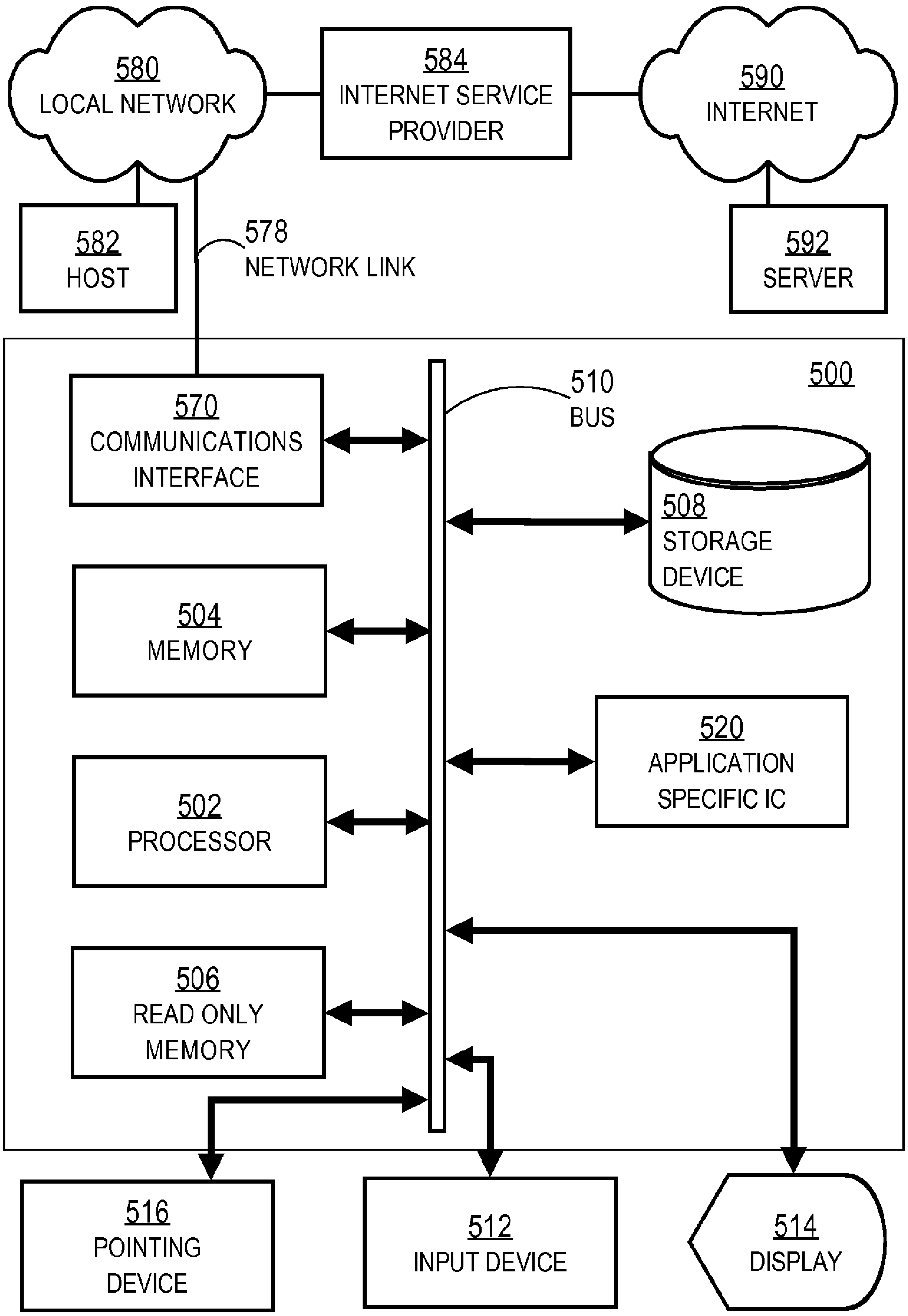

400
401
402
SELECT LEGACY SYSTEM AND INDICATE SAME
404
TAKE ANALOG MEDIUM FROM LIBRARY OF LEGACY SYSTEM AND LOAD INTO ANALOG PLAYER
408
SEND ANALOG OUTPUT THROUGH ANALOG TO DIGITAL (A/D) VIDEO CONVERTER TO PRODUCE DIGITAL VIDEO SIGNAL
410
RECEIVE LEGACY TEMPLATE DATA THAT INDICATES WHERE AND WHAT CHARACTERS ARE ON VIDEO IMAGE
412
RECEIVE DATA INDICATING LEGACY SYSTEM OF ANALOG MEDIUM BEING PLAYED
420
RECEIVE DIGITAL VIDEO SIGNAL
YES
490
MEDIUM END?
NO
430
DETERMINE CHARACTERS ON VIDEO IMAGE USING VIDEO OPTICAL CHARACTER RECOGNITION PROCESS
440
DETERMINE DESCRIPTIVE DATA BASED ON CHARACTERS
450
STORE DIGITAL VIDEO DATA IN ASSOCIATION WITH DESCRIPTIVE DATA IN DICOM OBJECT
460
DETERMINE BOUNDARY WITH NEXT PATIENT/SESSION

FIG. 5


580
LOCAL NETWORK
584
INTERNET SERVICE
PROVIDER
590
INTERNET
582
HOST
578
NETWORK LINK
592
SERVER
500
510
BUS
570
COMMUNICATIONS
INTERFACE
508
STORAGE
DEVICE
504
MEMORY
520
APPLICATION
SPECIFIC IC
502
PROCESSOR
506
READ ONLY
MEMORY
516
POINTING
DEVICE
512
INPUT DEVICE
514
DISPLAY

TECHNIQUES FOR CONVERTING ANALOG MEDICAL VIDEO TO DIGITAL OBJECTS

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims benefit of Provisional Appln. 60/799,295, filed May 10, 2006, under 35 U.S.C. §119(e).

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to converting analog medical video data to a digital object that associates descriptive data with the video, and, in particular, to forming Digital Imaging and Communications in Medicine (DICOM) objects from analog medical video data in a legacy data collection system.

2. Description of the Related Art

Medical care facilities collect video data in association with diagnostic and interventional radiological procedures, including fluorescence images of relative transmission and computer aided tomography (CAT) scan images based on Roentgen rays (X-rays), and echograms based on ultrasound. To associate each video clip with the patient and procedure for which the images were collected, characters were included in the recorded images that identified the patient-imaging session combination (called herein a patient-session identifier). Thus a human viewer of the video, such as a doctor could be assured that a particular video being viewed applied to a particular case under consideration.

Also associated with the video data is other information about the imaging session on the patient, such as the patient name or other identifier, the patient demographic data, e.g., age, height, weight, vital signs, family history, personal history, the imaging system identifier and maintenance history, the procedure itself, including study data when the imaging was performed as part of a study. This other descriptive data is stored separately from the video. For example, the non-video descriptive data was stored in journal entries or forms in a paper record, but more often as binary data on a computer storage medium in various files, sometimes within a database system.

These video data are archived as a record of the procedure, as a record of the patient's condition at the time of the procedure, and a baseline of patient condition to monitor the progression of a disease or a healing treatment. Several minutes to hours of such data is collected at a single medical facility for each of hundreds to thousands of patients per year, for many years.

In the past, the most efficient storage for such data has been as analog video data. Digital storage would require many terabytes of storage (a byte is about eight binary digits, called bits, a megabyte is a million bytes, and a terabyte is 10^{12} bytes—a million megabytes). Media such as hard magnetic disks for such data had limited capacity and were expensive. Vast numbers of such disks were required for digital storage. Analog formats could store more hours of data per medium and more cheaply. Many different such formats have been utilized from Beta-format video tapes, to standard VHS format video stapes, to proprietary formats defined for particular data collection systems. The analog data drives a television display using one of several worldwide standards, including PAL in Europe and NTSC in the United States. Several patient-session video clips are stored on a particular medium, typically a video tape, and the media are collected in libraries held at or for the benefit of each medical facility.

A variety of legacy and emerging systems have been used to collect video imaging data for patients, including, among others, systems from MERGE HEALTHCARE™ of Milwaukee, Wis.; Impax Master Patient Index (MPI) of AGFA HEALTHCARE™ of Mortsel, Belgium; Horizon Cardiology Echo of MCKESSON ALIPORT™ of Alpharetta, Ga.; Radiance Picture Archiving and Communication Systems (PACS) DEJARNETTE RESEARCH SYSTEMS, INC.™, of Towson, Md.; NAI DiCOM box CA+ Cine to DICOM of AMPRONIX INCORPORATED™, Irvine, Calif.; PACS systems of VEPRO™ of Hahn, Germany; CapturePRO systems of PEGASUS IMAGING CORPORATION™ of Tampa, Fla.; and Video Acquisition Workstation (VAW) of RAYPAX™ of Seoul, Korea.

When an archived video is to be reviewed for any reason, the appropriate volume of the medium must be identified, typically in a list or digital database, retrieved from the library, which can take several minutes if stored on site to several days if stored off site. Furthermore, a suitable player must be identified and located, the medium volume must be inserted, and the tape played forward until the correct clip is positioned in the viewer. There are costs associated with all these steps, not the least of which is the doctor's time in waiting for the appropriate clip to be positioned in the player after the data is requested. A significant cost to the patient's health and the doctor's inefficiency is the delay from the time that a need for the clip is identified until the proper medium volume is provided. Other costs include the librarian's salary, the salary of any other operators or technicians involved, the storage space for the media, the transportation costs between library and viewer, and the cost of maintaining the viewer, sometimes different viewers for different imaging systems. Such costs can often exceed a hundred thousand dollars a year.

Current digital storage techniques, such as hard magnetic drives and optical media such as DVDs, are now capable of efficiently storing such volumes of video data. An advantage of digital storage is that digital video data can now be stored in association with patient and procedure data related to the video data on the same storage medium. Data structures that combine multimedia data, images, sound, video, character and numeric data have been developed. Some are flexible enough to define their own fields. Object-oriented data bases define data objects that include not only data of different types, but also methods that are used for receiving input data, storing it, and retrieving it on request.

An object-oriented data format that has been adopted at many medical facilities is the Digital Imaging and Communications in Medicine (DICOM) system. DICOM is well known and widely used in the art of medical data and is available from the National Electrical Manufacturers Association (NEMA) of Rossyln, Va. Documentation of the DICOM standards is available at the time of this writing at subdomain dicom at domain nema at top level domain org as a Hypertext Markup Language (HTML) document ps3set.cfm in directory stds. The entire contents of ps3set.cfm are hereby incorporated by reference as if fully set forth herein.

There are benefits to converting the analog medical video data to digital data for storage in digital objects in association with other patient and procedure data, such as in DICOM objects. For example, the video and associated descriptive data can be retrieved over a network as soon as a need for it is identified, without intervention or costs of a human librarian or transporter, or the costs of one or more legacy analog video players, or the cost of time to advance a video tape. High capacity network digital storage is all that is required, and that is available reliably and cheaply as a commodity in current markets. The data can be kept indefinitely in a retrievable form independent of video players, even for the lifetime of a patient (many decades).

Unfortunately there are substantial obstacles in converting the analog data to digital form. Current systems involve a human operator playing each tape, determining the beginning and end of a clip associated with a single patient-imaging session, visually identifying the particular patient-imaging session based on the characters shown on the image, and retrieving data related to that patient-imaging session from one or more other digital files or databases. Then the portion of the tape must be played through an analog to digital converter and stored with the data from the database. Each legacy system would consume tens of thousands of hours of operator time (years of salary) to process all the video clips. Also, because the work is tedious and not related to a particular critical need of the patient whose data is being converted, the operator is prone to lose attention and to generate errors. Therefore the costs of the errors or checks to catch and correct errors would also be incurred. Again, these conversion costs can be expected to exceed a hundred thousand dollars a year for several years.

Based on the foregoing description, there is a clear need for techniques to convert large amounts of analog medical video data to digital objects that do not suffer the disadvantages of prior approaches. In particular, there is a need for techniques to convert analog medical video data to digital objects that involve very little human involvement.

The past approaches described in this section could be pursued, but are not necessarily approaches that have been previously conceived or pursued. Therefore, unless otherwise indicated herein, the approaches described in this section are not to be considered prior art to the claims in this application merely due to the presence of these approaches in this background section.

SUMMARY OF THE INVENTION

Techniques are provided for converting analog medical video data to digital objects. According to one set of embodiments, a method includes receiving a digital video signal produced by converting an analog video signal received in response to playing a recording of analog medical video collected for a legacy system on an analog video player compatible with the legacy system. Without human intervention, a first portion of a video frame of the digital video signal is determined where characters are imaged onto the analog medical video by the legacy system. The first portion of the video frame is processed in a video optical character recognition process to generate first character code data. Also without human intervention, non-video descriptive data associated with the analog medical video data is determined based on the first character code data. Still without human intervention, digital video data based on the digital video signal is stored in association with the non-video descriptive data, such as in a DICOM object.

In other sets of embodiments, a computer-readable medium, an apparatus and a system perform one or more steps of the above method.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention is illustrated by way of example, and not by way of limitation, in the figures of the accompanying drawings and in which like reference numerals refer to similar elements and in which:

FIG. **1** is a block diagram that illustrates a system for converting analog video data to digital objects with video and non-video data, according to an embodiment of the invention;

FIG. **2**A and FIG. **2**B are block diagrams that illustrate different areas for different character data used to identify patient demographic information associated with video data on different example legacy systems;

FIG. **3** is a block diagram that illustrates an example boundary between two patient imaging sessions;

FIG. **4** is a flow diagram that illustrates at a high level a method for converting analog medical video to combined digital data objects, according to an embodiment; and

FIG. **5** is a block diagram that illustrates an example computer system upon which an embodiment of the invention may be implemented.

DETAILED DESCRIPTION

Techniques are described for converting analog medical video data to digital objects. In the following description, for the purposes of explanation, numerous specific details are set forth in order to provide a thorough understanding of the present invention. It will be apparent, however, to one skilled in the art that the present invention may be practiced without these specific details. In other instances, well-known structures and devices are shown in block diagram form in order to avoid unnecessarily obscuring the present invention.

Some embodiments of the invention are descried below in the context of converting X-ray video clips to DICOM objects. However, the invention is not limited to this context. In other embodiments, the same or other data, such as ultrasound, laparoscopy, endoscopy, colonoscopy, interventional radiology and other video data are converted to the same or other digital objects, such as one or more digital database objects or files independent of a particular database.

1. Equipment Components

FIG. **1** is a block diagram that illustrates a system **100** for converting analog video data to digital objects with video and non-video data, according to an embodiment of the invention. System **100** includes a first library **110***a* and a second library **110***b* (collectively referenced hereinafter as analog libraries **110**) of legacy analog video media, such as legacy analog video medium **112**. System **100** also includes an analog media payer for each of the legacy libraries, e.g., analog player **120***a* and analog player **120***b* (collectively referenced hereinafter as analog players **120**) for media from library **110***a* and library **110***b*, respectively. System **100** also includes video analog to digital (A/D) converter **130** and computer **140**. System **100** includes patient-encounter information database **150** and DICOM object database **160** connected to computer **140** through local network **180**.

A library **110** is any archive of analog media, whether on site at the medical facility or offsite. The legacy analog video medium **112** is any medium used in a library and is considered uniform for all media in one library **110**. The medium **112** indicates a combination of both a physical medium, such as tape or disk, and the format for data on the physical medium. Different media are stored in different libraries. For example, the media in library **110***b* are different than the media in library **110***a*, although both libraries may be located in the same room or facility.

An analog player **120** is any device that is capable of producing an analog video signal from the legacy analog video medium. In some embodiments, the analog player **120** is part of a legacy system. In some embodiments, the analog player **120** is a common electronic device, such as a VHS player for NTSC video data that is compatible with the media produced by a legacy system. In an illustrated embodiment, analog players **120** are capable of playing legacy analog video medium at faster than real time, where real time is a play speed that renders realistic motion of objects represented in the stream of images that constitute the video data.

The video A/D converter **130** is any device that converts an analog signal to a digital signal. For example, digital video recorders (DVRs), such as TiVo devices from TIVO of Alviso, Calif., are configured to receive analog video for NTSC and record it in a digital format. Any digital format may be output by A/D converter **130**. Sample digital video formats include Motion Pictures Engineering Group (MPEG) video format, MPEG II format, MPEG IV format, all well known in the art. MPEG is a digital format that permits compression to various degrees, including lossless compression. In the illustrated embodiment, video A/D converter **130** is capable of converting analog video at faster than real time so that data output by the player **120** is not lost during conversion.

The patient-encounter information database **150** is any database with information to be associated with the video data. For example, database **150** includes information such as patient identifier, encounter identifier, procedure type, date of procedure, start time of procedure, duration of procedure, imaging device identifier, and identifier for imaging device operator. In an example embodiment, the patient-encounter information database **150** is a Radiology Information System (RIS). RIS includes patient demographics data and study demographics data, if any. In some embodiments, database **150** is simply a collection of one or more files with data of interest. In some embodiments, database **150** is a sophisticated database, such as a commercial relational database with data files and a server for responding to standard query language (SQL) commands.

The DICOM object database **160** is a database of DICOM objects that each combine photographic images and video clips with non-image character and numeric data. In some embodiments, database **160** is simply a collection of one or more files with DICOM objects. In some embodiments, database **160** is a sophisticated database, such as a commercial relational database with a server for responding to standard query language (SQL) commands.

The computer **140** and digital data are described in more detail in a later section. According to some embodiments of the invention, computer **140** includes a video-digital merge process **142** and legacy template data **144**. The video-digital merge process **142** associates non-video digital data with digital video clips produced by the video A/D converter **130**. The template data **144** associates different legacy systems with different areas on an image from a video clip where images of characters are included. In some embodiments, the template data also indicates the type of information (called herein a context or an attribute) for which the imaged characters represent a value. Video-digital merge process **142** is described in more detail below with reference to FIG. **4**. Template data **144** and its use, when included, are described in more detail below with reference to FIG. **2** and FIG. **4**.

Although two analog libraries **110** and associated analog players **120** are shown for purposes of illustration, in other embodiments a system includes fewer or more libraries **110** and analog players **120**, but at least one of each. Furthermore, although one patient-encounter information database **150** and one DICOM object database and one A/D converter **130** are shown, in other embodiments, more than one such database is included in a system and hybrid digital objects other than DICOM objects are stored in database **160** instead of or in addition to DICOM objects. Although one local network **180** is shown, in other embodiments more or fewer local networks or one or more wide area networks connect computer **140** to database **150**, or database **160**, or both. In some embodiments, digital video from video A/D converter **130** is communicated to computer **140** over a network, such as local area network **180**. In some embodiments, general purpose computer **140** is replaced by a special purpose computer, and one or more blocks shown as separate units are combined into a single unit. For example, in some embodiments A/D converter **130** and computer **140** are combined.

According to various embodiments of the invention, character data apparent in the images of the video frames is used to automatically associate a digital video clip with non-video descriptive data related to the video clip, and to automatically store a digital video clip in association with the non-video descriptive data in a second database, such as DICOM object database **160**.

2. Video Data

The video data processed by system **100** includes images of characters in one or more portions of each frame. A video clip, as is well known, is a series of images, called frames, taken at evenly separated times in rapid succession specified by a frame rate. Typical frame rates are on the order of 1 to 24 frames per second. An analog image represents controls to a cathode ray tube that sweeps across a television screen in interleaved groups of rows at a prescribed rate. The characteristics of the cathode ray that are controlled include intensity for monochrome video (so called "Black and White" video) and include color information, such as hue, for color video. Characters in such video, such as the letter "A" or the numeral "1" are recognizable to a human observer as uniform intensity or color spots on the screen that are positioned to produce character shapes.

Each image in a digital video is composed of indivisible picture elements (pixels) arranged in rows. A typical television image is well represented by 640 pixels in each of 480 rows. One octet (eight binary digits called bits) represents a range of grays from white to black in monochrome digital video. In color digital video, three octets each represent a range of intensities for one of three colors that mix to form one of millions of perceived colors. Characters in such video, such as the letter "A" or the numeral "1" are recognizable to a human observer as uniform intensity or color pixels on the screen that are positioned to produce character shapes.

Non-video digital data are series of values, such as binary octets, that code characters or numbers. A number can be represented directly in binary. Floating point number are a composite of two binary numbers, indicating a fraction and an exponent. Characters, including numerals, are represented indirectly by codes, where a different value represents a different character according to one of several standards, such as the ASCII standard, well known in the art, using binary codes. A series of one or more octets of binary codes may represent a number or a series of characters, depending on how the octets are used by a computer program.

An optical character recognition process is a computer program that examines the pixels in a digital image (such as a video frame) and determines whether the pixels are arranged in such a way as to represent a character. If so, the character so recognized is output by the process as the code for the character. Thus if pixels are arranged to create a yellow capital letter A in a digital image, the optical character recognition process outputs the code for the capital letter A, e.g. the octet "01000001" in the binary ASCII standard. To distinguish characters in images from code for characters, the former is called herein character image data and the latter is called character code data. To distinguish character code data from binary data that represents integers or floating point numbers, the latter is called herein numeric binary data. Note that character code data that represents numerals can be converted to numeric binary data. For example, ASCII characters that represent the numerals "1" followed by "3" (i.e., "00110001" followed by "00110011") can be converted to numeric binary data that represents the number thirteen, i.e., "1101."

According to embodiments of the invention, analog character image data is converted to digital character image data in A/D converter **130**; and then is converted in an optical character recognition process within the video-digital merge process **142** to character code data.

It is noted that the meaning of the characters detected in an image depends on the legacy system and possibly on the location of the characters. For example, one legacy system may image characters that represent a patient identifier (patient ID) and another legacy system may image characters that represent instead a case identifier (case ID) that is based on both a doctor and a patient visit. Some legacy systems may also image characters that represent the facility or the date or the time or some combination in addition to the patient ID or case ID or some combination.

FIG. **2**A and FIG. **2**B are block diagrams that illustrate different areas for different character data used to identify patient demographic information associated with video data on different example legacy systems.

FIG. **2**A is a block diagram that illustrates a video frame **201** of a first legacy system after conversion to digital video. The frame **201** holds an image **210** made up of pixels (not shown) that represent the internal structure of a patient. Superimposed on the representation of the patient's internal structure are locations where the analog image had been changed to represent character image data for one or more attributes. The character image data is found in each of several limited areas **212**, **214**, **216** of the image **210**. In a date-time character area **212**, characters indicate the date and time when the frame was recorded. In a patient ID character area **214**, characters indicate a patient ID for the patient whose internal structure is represented by the image **210**. In a doctor ID character area **216**, characters indicate a doctor ID for a doctor who is treating the patient indicated by the patient ID in area **214**. In all video collected by the first legacy system, the information for the date and time, patient ID and doctor ID attributes are placed as character image data in the areas **212**, **214**, **216**, respectively. The characters in the areas **212**, **214**, **216** change, but the context or attribute for those characters remains the same for the first legacy system, e.g., date-time, patient ID, doctor ID.

FIG. **2**B is a block diagram that illustrates a video frame **202** of a second legacy system after conversion to digital video. The frame **202** holds an image **220** made up of pixels (not shown) that represent the internal structure of a patient. Superimposed on the representation of the patient's internal structure are locations where the analog image had been changed to represent character image data. The character image data is found in each of several limited areas **222**, **228** of the image **210**. In elapsed time character area **222**, characters indicate the amount of time that passed since the start of the recording. In a encounter identifier (encounter ID) character area **228**, characters indicate a encounter ID that is a unique number for a combination of patient and the session with the imaging system that determines the internal structure represented by the image **220**. In all video collected by the second legacy system, the information for the elapsed time and encounter ID attributes are placed as character image data in the areas **222** and **228**, respectively. The characters in the areas **222**, **228** change, but the context or attribute for those characters remains the same for the second legacy system, e.g., elapsed time and encounter ID.

FIG. **3** is a block diagram that illustrates a boundary between two patient imaging sessions in a video frame sequence **300** from an example legacy system. The video sequence **300** includes successive frames (called a video clip). The first frame in the sequence includes a video frame with video frame image data **310***a*, followed by successive frames with video frame image data **310***b*, **310***c*, **310***d*, **310***e*, **310***f*, **310***g* and **310***h*. Video frame image **310***a* includes an octagon, diamond, trapezoid and pentagon that schematically represent the internal structure of a first patient. The image **310***a* also includes character data in area **312***a*. In the illustrated clip **300**, the character data indicates a device ID and date and time. Note that the location of the date-time in area **312***a* is different from that shown in FIG. **2**A and that no date-time area is shown in FIG. **2**B Thus FIG. **3** illustrates a video clip from a third different legacy system.

The successive frames of clip **300** include the video frame images **310***b*, **310***c*, **310***d*, **310***e*, **310***f*, **310***g*, **310***h*, respectively. The date and time, if available, for each frame is shown in areas **312***b*, **312***c*, **312***d*, **312***e*, **312***f*, **312***g*, **312***h*, respectively. Areas **312***a* through **312***h* are collectively referenced hereinafter as character area **312**.

The clip **300** depicts a boundary between video data for a first encounter with a first patient and a different encounter with the same or different patient. Images **310***b* and **310***c* belong to the first encounter and are similar to image **310***a*. The size and positions of the polygons representing internal structure change slightly among images **310***a*, **310***b*, **310***c*. Images **310***f*, **310***g*, **310***h* belong to a different second encounter. Video frame image **310***f* includes a rounded-corner rectangle, rotated rectangle, irregular shape and oval that represent the internal structure of the second patient, and that correspond to the octagon, diamond, trapezoid and pentagon that represent the internal structure of a first patient. Between images **310***c* and **310***f* are two images **310***d*, **310***e* without image data indicating internal structure of a patient, such as occurs in a video clip recorded during no input data or during a fade out recording mode.

As described in more detail below, in some embodiments, the changes in image content from image **310***c* to images **310***d*, **310***e* and then to image **310***f* are used to detect the boundary between different patient encounters on an imaging device. Although some particular characteristics of the boundary are shown in FIG. **3** for purposes of illustration, in other embodiments more, fewer or different changes occur at the boundary between imaging sessions of patients.

3. Video-Digital Merge Process

FIG. **4** is a flow diagram that illustrates at a high level a method **400** for converting analog medical video to combined digital data objects, according to an embodiment. Although steps are shown in FIG. **4** in a particular order for purposes of illustration, in other embodiments, the steps may be performed in a different order, or overlapping in time by one or more parallel or serial processes, or some steps may be omitted, or some combination of changes may be involved.

Method **400** includes step **401** that is performed manually in some embodiments and automatically in other embodiments. Method **400** also includes step **408** that is performed by analog player (e.g., player **120**) and A/D converter (e.g., A/D converter **130**). Method **400** also includes steps **410** through **490** that are performed by the video-digital merge process (e.g., process **142**) on one or more processors, such as one or more processors on computer **140**.

In step **410**, legacy template data (e.g., data **144** on computer **140**) is received that indicates the location of character areas on a video frame and the context or attribute for those characters for each legacy system of interest. For example, template data is received for three legacy systems. The example template data indicates that in the first legacy system the character areas **212**, **214**, **216** are used for date-time, patient ID and doctor ID, respectively. The example template data indicates that in the second legacy system the character areas **222**, **228** are used for elapsed time and encounter ID, respectively. The example template data also indicates that in the third legacy system the character area **312** is used for device ID and date and time, in that order.

Any method may be used to receive the template data. In various embodiments, the template data is predefined and stored within source code or in files stored with the executable code or in files or a database accessible to the merge process. In some embodiments, the data is received at the time of execution, such as when input manually or when received in a message from a different local or remote process either in response to a prompt or query message, or unsolicited.

In an illustrated embodiment, step **401** is performed manually by a human operator and includes steps **402** and **404**. In step **402** a legacy system library is selected and indicated to the merge process, for example by selecting options from a graphical user interface on computer **140** or remotely on a computer connected to local area network **180**.

In step **404**, a medium from the library for the legacy system selected in step **401** is inserted into an analog video player compatible with the legacy system. For example medium **112** is taken from library **110***a* and inserted into player **120***a*.

In some embodiments, step **401** is performed by an automated system that controls a robotic arm. The controller causes the robotic arm to select a medium from a library and insert the medium into an appropriate player. In some of these embodiments, the controller selects the medium according to a program, such as a program to go in order through every tape in a library. In some of these embodiments, the controller indicates the legacy system from which media are being loaded to the merge process (e.g., process **142** on computer **140**).

In step **408** the analog video output from the player (e.g., player **120***a*) is input to the video A/D converter (e.g., converter **130**). This can be done in any way. For example, a cable from player **120***a* is connected to an input port of A/D converter **130** in some embodiments. In some embodiments, a switch that connects both players **120***a* and **120***b* to A/D converter **130** is thrown to cause output from player **120***a* to feed into A/D converter **130**. The switch may be internal to A/D converter **130** or external (not shown). In some embodiments, connections are hardwired and step **408** is omitted.

In step **412**, legacy data that indicates the legacy system that is the source of the analog data is received at the merge process. In various embodiments, the legacy data is received in response to step **402** performed manually or automatically by a controller for a robotic arm. For example, data is received at merge process **142** that indicates the legacy system is the third legacy system that produces video like that shown in FIG. **3**.

In step **420**, digital video is received at the merge process (e.g., process **142** on computer **140**). For example, the video clip shown in FIG. **3** is received by process **142**.

In step **430**, character code data is produced based on the digital video received in step **420**. In the illustrated embodiment, step **430** includes determining the portion of the image of the current frame that holds character data based on the template data and the legacy data. For example, merge process **142** determines from the legacy data that the third legacy system is the source of the video. The merge process then determines from template data **144** that the third legacy system uses area **312** to report the device and date and time that recorded the video. The area **312** is fed into a video optical character recognition (video OCR) process to output character code data for the sequence of characters found in area **312**. Any OCR known in the art may be used to generate character code data from the character image data in the image area of interest, e.g. area **312**.

In step **440**, non-video descriptive data for the video clip is determined based on the character code data. In some embodiments, the descriptive data is the same as the character code data. For example, in some embodiments, the device ID "XQ123" and the start date "12/02/1995" and time "11:18:52.1" of the first image **310***f* for the session is used as the descriptive data. In some embodiments, data based on the character code data is used as the descriptive data. For example, procedure duration is non-video descriptive data derived from the difference between the time of the first frame and the time of the last frame for the session.

In some embodiments, step **440** includes retrieving data from a database (e.g., patient encounter database **150**) based on the character code data. For example, the date and device is used in an SQL query to database **150** to find a patient encounter record that used that device at that time. Then other information from that record is retrieved as non-video descriptive data. For example, based on device ID XQ123, date 12/02/95 and time 11:18:52.1, patient demographic data and test demographic data are retrieved from database **150**. Patient demographic data describes the patient and the population of which the patient is a member, such as the patient's age, height, weight, race, zip code, insurance type, among others. The database may also include patient particular data, such as name, ID, social security number, address, telephone number, insurer, among others. Study demographics describe the measurement group, such as disease, treatment, population size, study duration, study start date, among others.

In some embodiments, the character code data indicates a primary index into the database **150**. For example, in some embodiments, the character code data retrieved from the encounter ID character area **228** for the second legacy system is also an index into a Radiology Information System (RIS) database.

In step **450**, the digital video data is stored in association with the descriptive data in a database (e.g., DICOM database **160**). In some embodiments, step **450** involves storing the digital video data on database **160** along with a pointer to one or more records in database **150**. In the illustrated embodiment, step **450** comprises forming a DICOM object that includes the digital video for the session in a "CINE" field along with binary data for characters and numbers retrieved from the RIS **150** in one or more other fields to indicate non-video descriptive data associated with the video data (often called metadata, i.e., data about data); and storing the composite DICOM object in database **160**.

In step **460** a boundary between the current patient session video data and a different patient session video data is determined. Any method may be used. In some embodiments, a set of one or more frames with no image data is determined to be a boundary. For example, images **310***d*, **310***e* of clip **300** are determined to have no image data and therefore serve as a boundary between a first session and a second session.

In some embodiments, the first image after the no image frame or frames is compared to the last image before the no image frame or frames. A measure of similarity between the two images is determined. Any measure of similarity may be used. For example, a correlation between the two images is determined. If the measure of similarity is above some threshold, the two images are judged to belong to the same patient session. In such a case, any intervening frames without image data will not be considered a boundary between two sessions. If the measure of similarity is below that threshold, then one of the intervening frames without image data is considered a boundary.

In some embodiments, there are not frames without image data between sessions. In such embodiments, the measure of similarity can be used to determine a boundary. For example, a measure of similarity among images **310***a* to **310***c* is greater than a measure of similarity between images **310***c* and **310***f*. Therefore, the frame of image **310***f* is judged to start a different session in some embodiments.

In some embodiments, a large change in any character code data determined from successive frames can be used to determine a boundary between sessions. For example, the time difference among successive images **310***a*, **310***b*, **310***c* is about 0.1 seconds; but the time difference between image **310***c* and image **310***f* is more than eight minutes. Therefore, in some embodiments it is judged that a session boundary occurs between the frame of image **310***c* and the frame of image **310***f*.

Control then passes to step **490**. In step **490** it is determined whether the end of data on the medium has been reached. If so, control passes to step **404** to insert another medium into the analog player. If it is determined in step **490** that there is more data on the current medium, then control passes to step **430** to determine the character code data for the next session on the current medium.

In some embodiments, in which all analog data to be converted use the same legacy system or several systems are all compatible with the same legacy system in terms of video media and location and context of character areas, steps **402**, **410** and **412** can be omitted. The system **100** is set up at one time and takes all character image data from the same area of each frame and interprets the resulting character code data in the same context or as the same attribute.

In some embodiments, the medium play rate in step **404** and processing during steps **420** through **490** are performed at faster than real time.

Using the steps of method **400** with the apparatus of system **100**, large libraries of analog video data from legacy systems can be converted to digital objects with little or no human involvement. This saves the cost of human salaries and the cost of human errors and the cost of delays between the request and the viewing of the data. When data is desired after conversion, it is retrieved immediately over network **180** from DICOM OBJECT database

4. Computer Hardware Overview

FIG. **5** is a block diagram that illustrates a computer system **500** upon which an embodiment of the invention may be implemented. Computer system **500** includes a communication mechanism such as a bus **510** for passing information between other internal and external components of the computer system **500**. Information is represented as physical signals of a measurable phenomenon, typically electric voltages, but including, in other embodiments, such phenomena as magnetic, electromagnetic, pressure, chemical, molecular atomic and quantum interactions. For example, north and south magnetic fields, or a zero and non-zero electric voltage, represent two states (0, 1) of a binary digit (bit). A sequence of binary digits constitutes digital data that is used to represent a number or code for a character. A bus **510** includes many parallel conductors of information so that information is transferred quickly among devices coupled to the bus **510**. One or more processors **502** for processing information are coupled with the bus **510**. A processor **502** performs a set of operations on information. The set of operations include bringing information in from the bus **510** and placing information on the bus **510**. The set of operations also typically include comparing two or more units of information, shifting positions of units of information, and combining two or more units of information, such as by addition or multiplication. A sequence of operations to be executed by the processor **502** constitute computer instructions.

Computer system **500** also includes a memory **504** coupled to bus **510**. The memory **504**, such as a random access memory (RAM) or other dynamic storage device, stores information including computer instructions. Dynamic memory allows information stored therein to be changed by the computer system **500**. RAM allows a unit of information stored at a location called a memory address to be stored and retrieved independently of information at neighboring addresses. The memory **504** is also used by the processor **502** to store temporary values during execution of computer instructions. The computer system **500** also includes a read only memory (ROM) **506** or other static storage device coupled to the bus **510** for storing static information, including instructions, that is not changed by the computer system **500**. Also coupled to bus **510** is a non-volatile (persistent) storage device **508**, such as a magnetic disk or optical disk, for storing information, including instructions, that persists even when the computer system **500** is turned off or otherwise loses power.

Information, including instructions, is provided to the bus **510** for use by the processor from an external input device **512**, such as a keyboard containing alphanumeric keys operated by a human user, or a sensor. A sensor detects conditions in its vicinity and transforms those detections into signals compatible with the signals used to represent information in computer system **500**. Other external devices coupled to bus **510**, used primarily for interacting with humans, include a display device **514**, such as a cathode ray tube (CRT) or a liquid crystal display (LCD), for presenting images, and a pointing device **516**, such as a mouse or a trackball or cursor direction keys, for controlling a position of a small cursor image presented on the display **514** and issuing commands associated with graphical elements presented on the display **514**.

In the illustrated embodiment, special purpose hardware, such as an application specific integrated circuit (IC) **520**, is coupled to bus **510**. The special purpose hardware is configured to perform operations not performed by processor **502** quickly enough for special purposes. Examples of application specific ICs include graphics accelerator cards for generating images for display **514**, cryptographic boards for encrypting and decrypting messages sent over a network, speech recognition, and interfaces to special external devices, such as robotic arms and medical scanning equipment that repeatedly perform some complex sequence of operations that are more efficiently implemented in hardware.

Computer system **500** also includes one or more instances of a communications interface **570** coupled to bus **510**. Communication interface **570** provides a two-way communication coupling to a variety of external devices that operate with their own processors, such as printers, scanners and external disks. In general the coupling is with a network link **578** that is connected to a local network **580** to which a variety of external devices with their own processors are connected. For example, communication interface **570** may be a parallel port or a serial port or a universal serial bus (USB) port on a personal computer. In some embodiments, communications interface **570** is an integrated services digital network (ISDN) card or a digital subscriber line (DSL) card or a telephone modem that provides an information communication connection to a corresponding type of telephone line. In some embodiments, a communication interface **570** is a cable modem that converts signals on bus **510** into signals for a communication connection over a coaxial cable or into optical signals for a communication connection over a fiber optic cable. As another example, communications interface **570** may be a local area network (LAN) card to provide a data communication connection to a compatible LAN, such as Ethernet. Wireless links may also be implemented. For wireless links, the communications interface **570** sends and receives electrical, acoustic or electromagnetic signals, including infrared and optical signals, that carry information streams, such as digital data. Such signals are examples of carrier waves.

The term computer-readable medium is used herein to refer to any medium that participates in providing information to processor **502**, including instructions for execution. Such a medium may take many forms, including, but not limited to, non-volatile media, volatile media and transmission media. Non-volatile media include, for example, optical or magnetic disks, such as storage device **508**. Volatile media include, for example, dynamic memory **504**. Transmission media include, for example, coaxial cables, copper wire, fiber optic cables, and waves that travel through space without wires or cables, such as acoustic waves and electromagnetic waves, including radio, optical and infrared waves. Signals that are transmitted over transmission media are herein called carrier waves.

Common forms of computer-readable media include, for example, a floppy disk, a flexible disk, a hard disk, a magnetic tape, or any other magnetic medium, a compact disk ROM (CD-ROM), a digital video disk (DVD) or any other optical medium, punch cards, paper tape, or any other physical medium with patterns of holes, a RAM, a programmable ROM (PROM), an erasable PROM (EPROM), a FLASH-EPROM, or any other memory chip or cartridge, a carrier wave, or any other medium from which a computer can read.

Network link **578** typically provides information communication through one or more networks to other devices that use or process the information. For example, network link **578** may provide a connection through local network **580** to a host computer **582** or to equipment **584** operated by an Internet Service Provider (ISP). ISP equipment **584** in turn provides data communication services through the public, world-wide packet-switching communication network of networks now commonly referred to as the Internet **590**. A computer called a server **592** connected to the Internet provides a service in response to information received over the Internet. For example, server **592** provides information representing video data for presentation at display **514**.

The invention is related to the use of computer system **500** for implementing the techniques described herein. According to one embodiment of the invention, those techniques are performed by computer system **500** in response to processor **502** executing one or more sequences of one or more instructions contained in memory **504**. Such instructions, also called software and program code, may be read into memory **504** from another computer-readable medium such as storage device **508**. Execution of the sequences of instructions contained in memory **504** causes processor **502** to perform the method steps described herein. In alternative embodiments, hardware, such as application specific integrated circuit **520**, may be used in place of or in combination with software to implement the invention. Thus, embodiments of the invention are not limited to any specific combination of hardware and software.

The signals transmitted over network link **578** and other networks through communications interface **570**, which carry information to and from computer system **500**, are exemplary forms of carrier waves. Computer system **500** can send and receive information, including program code, through the networks **580**, **590** among others, through network link **578** and communications interface **570**. In an example using the Internet **590**, a server **592** transmits program code for a particular application, requested by a message sent from computer **500**, through Internet **590**, ISP equipment **584**, local network **580** and communications interface **570**. The received code may be executed by processor **502** as it is received, or may be stored in storage device **508** or other non-volatile storage for later execution, or both. In this manner, computer system **500** may obtain application program code in the form of a carrier wave.

Various forms of computer readable media may be involved in carrying one or more sequence of instructions or data or both to processor **502** for execution. For example, instructions and data may initially be carried on a magnetic disk of a remote computer such as host **582**. The remote computer loads the instructions and data into its dynamic memory and sends the instructions and data over a telephone line using a modem. A modem local to the computer system **500** receives the instructions and data on a telephone line and uses an infra-red transmitter to convert the instructions and data to an infra-red signal, a carrier wave serving as the network link **578**. An infrared detector serving as communications interface **570** receives the instructions and data carried in the infrared signal and places information representing the instructions and data onto bus **510**. Bus **510** carries the information to memory **504** from which processor **502** retrieves and executes the instructions using some of the data sent with the instructions. The instructions and data received in memory **504** may optionally be stored on storage device **508**, either before or after execution by the processor **502**.

5. Extensions and Alternatives

In the foregoing specification, the invention has been described with reference to specific embodiments thereof. It will, however, be evident that various modifications and changes may be made thereto without departing from the broader spirit and scope of the invention. The specification and drawings are, accordingly, to be regarded in an illustrative rather than a restrictive sense.

What is claimed is:

1. A method for converting analog medical video data to digital objects, comprising the steps of:

a. receiving a digital video signal produced by converting an analog video signal received in response to playing a recording of analog medical video associated with a legacy system on an analog video player compatible with the legacy system;

b. determining without human intervention a first portion of a video frame of the digital video signal where characters are imaged onto the analog medical video by the legacy system, wherein the first portion is associated with a particular context for the legacy system;

c. processing the first portion of the video frame in a video optical character recognition process to generate first character code data;

d. determining without human intervention non-video descriptive data associated with the analog medical video data based on the first character code data and the particular context; and

e. storing without human intervention digital video data based on the digital video signal in association with the non-video descriptive data.

2. A method as recited in claim **1**, wherein:

the method further comprises

receiving legacy template data that associates a plurality of portions of a video frame with a corresponding plurality of different legacy systems, and

receiving legacy type data that indicates among the plurality of different legacy systems a particular legacy system that stored the analog medical video data; and

said step of determining the first portion of the video frame further comprises determining the first portion of the video frame based on the legacy type data and the legacy template data.

3. A method as recited in claim **1**, wherein:

said step of determining the first portion of the video frame further comprises determining the first portion of the video frame where characters are imaged to indicate an index into a database of patient encounter information; and

said step of determining non-video descriptive data associated with the analog medical video data further comprising retrieving the non-video descriptive data from the database of patient encounter information based on the index into the database.

4. A method as recited in claim **1**, said step of storing digital video data based on the digital video signal further comprising the step of storing the digital video data and the non-video descriptive data together in a single Digital Imaging and Communications in Medicine (DICOM) object.

5. A method as recited in claim **1**, further comprising determining without human intervention a boundary in the digital video signal between first video data collected for a first imaging session with a first patient and different video data collected for a different second imaging session with a second patient.

6. A method as recited in claim **5**, further comprising repeating steps b, c, d and e for the different video data collected for the different second imaging session with the second patient.

7. A method as recited in claim **5**, wherein the second patient is the same as the first patient.

8. A method as recited in claim **1**, wherein the non-video descriptive data includes at least one of patient identifier, encounter identifier, procedure type, date of procedure, start time of procedure, duration of procedure, imaging device identifier, or identifier for imaging device operator.

9. A non-transitory computer-readable medium carrying one or more sequences of instructions for converting analog medical video data to digital objects, wherein execution of the one or more sequences of instructions by one or more processors causes the one or more processors to perform the steps of:

a. receiving a digital video signal produced by converting an analog video signal received in response to playing a recording of analog medical video associated with a legacy system on an analog video player compatible with the legacy system;

b. determining a first portion of a video frame of the digital video signal where characters are imaged onto the analog medical video by the legacy system, wherein the first portion is associated with a particular context for the legacy system;

c. processing the first portion of the video frame in a video optical character recognition process to generate first character code data;

d. determining non-video descriptive data associated with the analog medical video data based on the first character code data and the particular context; and

e. storing digital video data based on the digital video signal in association with the non-video descriptive data.

10. A computer-readable medium as recited in claim **9**, wherein:

execution of the one or more sequences of instructions further causes the one or more processors to perform the steps of

receiving legacy template data that associates a plurality of portions of a video frame with a corresponding plurality of different legacy systems, and

receiving legacy type data that indicates among the plurality of different legacy systems a particular legacy system that stored the analog medical video data; and

said step of determining the first portion of the video frame further comprises determining the first portion of the video frame based on the legacy type data and the legacy template data.

11. A computer-readable medium as recited in claim **9**, wherein:

said step of determining the first portion of the video frame further comprises determining the first portion of the video frame where characters are imaged to indicate an index into a database of patient encounter information; and

said step of determining non-video descriptive data associated with the analog medical video data further comprising retrieving the non-video descriptive data from the database of patient encounter information based on the index into the database.

12. A computer-readable medium as recited in claim **9**, said step of storing digital video data based on the digital video signal further comprising the step of storing the digital video data and the non-video descriptive data together in a single Digital Imaging and Communications in Medicine (DICOM) object.

13. A computer-readable medium as recited in claim **9**, wherein execution of the one or more sequences of instructions further causes the one or more processors to perform the step of determining without human intervention a boundary in the digital video signal between first video data collected for a first imaging session with a first patient and different video data collected for a different second imaging session with a second patient.

14. A computer-readable medium as recited in claim **13**, wherein execution of the one or more sequences of instructions further causes the one or more processors to perform the steps of repeating steps b, c, d and e for the different video data collected for the different second imaging session with the second patient.

15. A computer-readable medium d as recited in claim **13**, wherein the second patient is the same as the first patient.

16. A computer-readable medium as recited in claim **9**, wherein the non-video descriptive data includes at least one of patient identifier, encounter identifier, procedure type, date of procedure, start time of procedure, duration of procedure, imaging device identifier, or identifier for imaging device operator.

17. A system for converting analog medical video data to digital objects comprising:

a video analog to digital converter;

one or more computer-readable media;

one or more processors; and

one or more sequences of instructions stored on the one or more computer-readable media, wherein execution of the one or more sequences of instructions by the one or more processors causes the one or more processors to perform the steps of:

receiving from the video analog to digital converter a digital video signal produced by converting an analog video signal received in response to playing a recording of analog medical video associated with a legacy system on an analog video player compatible with the legacy system;

determining a first portion of a video frame of the digital video signal where characters are imaged onto the analog medical video by the legacy system, wherein the first portion is associated with a particular context for the legacy system;

processing the first portion of the video frame in a video optical character recognition process to generate first character code data;

determining non-video descriptive data associated with the analog medical video data based on the first character code data and the particular context; and

storing, on the one or more computer-readable media, digital video data based on the digital video signal in association with the non-video descriptive data.

18. A system as recited in claim **17**, further comprising the analog video player compatible with the legacy system.

19. A system as recited in claim **18**, further comprising an automated media retrieval system for retrieving without human intervention media that holds the recording of analog medical video associated with the legacy system and inserting the media into the analog video player.

20. A system as recited in claim **17**, wherein:

said step of determining the first portion of the video frame further comprises determining the first portion of the video frame where characters are imaged to indicate an index into a database of patient encounter information; and

said step of determining non-video descriptive data associated with the analog medical video data further comprising retrieving the non-video descriptive data from the database of patient encounter information based on the index into the database.

* * * * *